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CHLORIDE INPUTS TO LAKE ONTARIO AND THE SIGNIFICANCE OF DEICING SALTS

April 1978

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Ministry of the Environment

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CHLORIDE INPUTS TO LAKE ONTARIO AND THE SIGNIFICANCE OF DEICING SALTS

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Water Resources Branch
April, 1978

165

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TABLE OF CONTENTS

	Page
Abstract	1
Acknowledgements	1
Introduction	2
Deicing Chemicals	3
Amount of Salt Used for Deicing Operations	4
Chloride Loadings to Lake Ontario from Ontario Sources	5
Tributary Streams	
STPs	
Industry	
Atmosphere	
Deicing Salt Application	
Summary	
Environmental Significance	9
Criteria	
Chlorides in Watercourses	
Chlorides in Lake Ontario	
Chloride Inputs from New York State	18
Discussion	19
Appendix	21

LIST OF FIGURES

Figure		Page
1	Chloride Concentration Profile for the Credit River (semi-urban stream)	12
2	Chloride Concentration Profile for Etobicoke Creek (urban stream)	13
3	Chloride Concentration Profile for the Don River (urban stream)	14
4	Chloride Concentration Profile for Duffins Creek (semi-urban stream)	15
5	Chloride Concentration Profile for Salem Creek (rural basin)	16
6	Changes in the Chloride Concentration of Lake Ontario (after Beeton, 1965)	17

LIST OF TABLES

Table		Page
I	Summary of Deicing Salt Used in Lake Ontario Drainage Basin	4
II	Summary of Total and Baseline Chloride Loadings from Tributary Streams	5
III	Summary of Total and Baseline Chloride Loadings from Sewage Treatment Plants Discharging Directly to Lake Ontario	6
IV	Summary of Measured Chloride Inputs to Lake Ontario (Excluding Deicing Salt Contribution)	7
V	Summary of Chloride Loadings from Deicing Salt Application	7
VI	Relative Significance of Sources of Chlorides (Averaged for the Study Period 1973-1977)	8
VII	Chloride Loadings from Three New York State Tributary Streams	18

APPENDIX
LIST OF TABLES

Table		Page
IA	Salt Applied by Towns and Municipalities.....	21
IIA	Salt Applied by the Ministry of Transportation and Communications.....	22
IIIA	Chloride Loadings from Tributary Streams.....	23
IVA	Chloride Loadings from Sewage Treatment Plants.....	24
VA	Chloride Concentrations in Streams in and Around Metro Toronto.....	25

ABSTRACT

Deicing salt (primarily rock salt) used for winter roadway maintenance is the largest single source of chlorides entering Lake Ontario from local Ontario sources. It represents 45% of the total loading compared to 29% from tributary drainage, 14% and 9% respectively from sewage treatment plants and industries discharging directly to the lake and 3% from atmospheric sources.

In Lake Ontario, however, the chloride loading and water quality impact from deicing salt application are relatively insignificant when compared to the chloride loading carried by the Niagara River. There is no evidence to suggest that the growing use of deicing salt over the past 30 years has significantly affected water quality or use in Lake Ontario.

On the other hand, large fluctuations and high winter chloride concentrations have been measured in watercourses flowing through the Metropolitan Toronto area. While the lower reaches of these watercourses are not used for purposes sensitive to chloride levels such as water supply or irrigation, the impact from a large municipal development in the headwater or upper reaches of a river basin could impair or restrict downstream uses.

With the public's expectation of "safe" winter roadway conditions and until satisfactory alternatives to road salt are found, deicing salt will continue to be a large local source. Salt conservation practices as outlined in the Ministry of the Environment's "Guidelines for Snow Disposal and Deicing Operations in Ontario" will minimize unnecessary use and losses of rock salt.

ACKNOWLEDGEMENTS

The Ontario Ministry of the Environment gratefully acknowledges the assistance of the southern Ontario municipalities in the Lake Ontario basin for providing salt application records and other data necessary for the preparation of this report. Similarly, the assistance of staff from the Ontario Ministry of Transportation and Communications in providing highway salting information is appreciated.

INTRODUCTION

The purpose of this report is to illustrate the relative significance of the contribution of chlorides from deicing salt when compared to the other local sources: domestic sewage, industrial waste, land runoff and the atmosphere, in the Province of Ontario's portion of the Lake Ontario drainage basin.

Since the end of World War II, there has been a steady growth in the number of motor vehicles and the construction of paved streets and highways. With increasing traffic densities and the necessity of winter travel, came the public demand for the removal of snow and ice from road surfaces. In concert with plowing, salt is employed to achieve bare, "safe" roadway conditions in those areas where winter temperatures are satisfactory for effective rock salt use.

The Lake Ontario Basin, with its large population centres, thousands of miles of paved highways, snowfalls generally in excess of 150 cm and winter temperature suitable for salt use, is quite suitable for a comparison of chloride from deicing salt and other major sources.

The Ontario Ministry of the Environment records of chloride loadings from sewage treatment plants, industries, tributary streams and the atmosphere were used for comparison.

Deicing salt application varies significantly from year to year depending upon the number of snowfalls and general climatological conditions. To obtain a cross-section of such conditions, the data presented in this report are for the four winters from 1973-74 to 1976-77.

All loadings are expressed in metric tonnes which are equivalent to 1000 kilograms (2205 pounds).

DEICING CHEMICALS

Sodium chloride (rock salt) is the most widely used deicing agent. It is composed of 94-97% pure sodium chloride and small quantities of chlorides, carbonates and sulphates of calcium and magnesium. Rock salt is about 60% chloride.

Sodium chloride is efficient as a deicing agent at temperatures above -20°C (-4°F). It is easily handled and low in cost ($15-20 per tonne) when compared to other deicing chemicals.

Calcium chloride is used also to a limited extent as a deicing agent. It is effective to temperature of -34°C (-30°F) but is not as widely used as sodium chloride because of its relatively high cost (over $80 per tonne).

Deicing salt can cause a number of adverse environmental effects. The problems usually cited include:

1. contributing to the corrosion of highway structures and vehicles;
2. contamination of surface and subsurface water supplies (particularly in the vicinity of inadequate storage areas);
3. contamination of soils and damage to trees and other vegetation near roadway right-of-ways.

The environmental impacts of salt are discussed in the 1974 publication produced by the Ministry of the Environment entitled "A Review of Literature on the Environmental Impact of Deicing Compounds and Snow Disposal".

There are a number of alternatives to using salt. Sand and gravel is used in northern and rural areas where the colder temperatures make rock salt less effective and traffic densities are lighter. While effective when first applied, sand may be quickly blown from roadways by wind and traffic leaving bare ice or packed snow. A mixture of sand and salt is often effectively used but wide-scale use within large municipalities is limited because of the damage and maintenance problem sand can cause in sewer systems.

Urea, a nitrogen compound, is used as the alternative to deicing salt on a limited basis. One area of use is airport runways where deicing salts cannot be employed because of their corrosive properties. Urea is about 10 times the cost of rock salt and because of its less effective melting ability, it must be used in much larger quantities. Because of these factors, urea is not widely used as a roadway deicer. Widespread use of urea could result in significant buildup of the nutrient nitrogen in watercourses causing much more serious problems than chlorides now present.

Other alternatives such as heating or covering roadways are very expensive and currently not practical for anything more than parking lot ramps, etc.

AMOUNT OF SALT USED FOR DEICING OPERATIONS

In order to estimate the amount of salt from deicing operations entering Lake Ontario from Ontario, the towns and cities in the basin were contacted. The total amount of salt used by the various municipalities for the winters 1973-74 to 1976-77 is presented in Table 1A of the Appendix. Totals for each winter period are 213,683, 208,901, 270,840, and 295,545 tonnes respectively. Quite clearly this reflects the year to year fluctuations in deicing salt use.

The amount of salt used by the Ministry of Transportation and Communication (MTC) on the provincial highway system, is presented in Table IIA of the Appendix. The amount used on highways in Lake Ontario basin for the winter periods 1973-74 to 1976-77 are 86,680, 97,190, 118,810, 110,110 tonnes respectively.

The amount of salt used by home owners on driveways and sidewalks was estimated by assuming that each household used a 25 lb. bag of salt per winter. The number of households in the towns and cities polled for deicing salt usage were estimated from the Municipal Directory prepared by the Ministry of Treasury Economics and Intergovernmental Affairs. The total for each winter period from 1973-74 to 1976-77 is 14,685, 15,076, 15,385, and 15,534 tonnes respectively.

Table I: Summary of Deicing Salt Used in Lake Ontario Drainage Basin

	1973-74	1974-75	1975-76	1976-77
Municipalities	213,683	208,901	270,840	295,545
MTC	86,680	97,190	118,810	110,110
Driveway & sidewalks	14,685	15,076	15,385	15,534
TOTAL	315,048	321,167	405,035	421,189

CHLORIDE LOADINGS TO LAKE ONTARIO FROM ONTARIO SOURCES

CHLORIDES FROM TRIBUTARY STREAMS

All rivers and streams with significant flow draining to Lake Ontario were included in this review and are listed in Table IIIA of the Appendix. Information on chloride levels in each tributary for each study year was obtained from water quality monitoring records of the Ministry of the Environment. Continuous streamflow records of the Water Survey of Canada (Environment Canada) were employed wherever possible and supplemented with selected streamflow data collected by the Ministry of the Environment. (Annual chloride loadings were calculated by multiplying annual average streamflows by annual average chloride concentrations.)

Part of the tributary stream chloride loadings, particularly from tributaries draining larger municipalities, is directly related to the application of deicing salt. To separate the deicing salt component from the other chloride sources within a tributary basin (STP and the industrial discharge, land drainage, etc.) the baseline chloride concentration was established by determining the average concentration for the period May through October when deicing salt was not being applied. The annual baseline chloride loading was calculated by multiplying the annual average baseline concentration by the annual average streamflow.

Table II: Summary of Total and Baseline Chloride Loadings from Tributary Streams*

Year	Total Chloride Loadings tonnes/year	Baseline Chloride Loadings tonnes/year
1973	287,891	153,509
1974	374,529	148,604
1975	275,726	128,664
1976	298,338	131,156

*includes inland STPS and industrial sources.

CHLORIDES FROM SEWAGE TREATMENT PLANTS (STPs)

Treated discharges from municipal sewage treatment plants contain chlorides which originate with domestic sewage and some industrial wastes. Chloride, for the most part, is dissolved in water and not removed by conventional treatment processes in use today. Chloride levels range from about 50 to 150 mg/l with the larger plants usually having the higher levels.

Total chloride loadings from sewage treatment plants discharging directly to Lake Ontario were calculated by multiplying annual average chloride concentration by annual average sewage flows for each plant. These are listed in Table IVA of the Appendix. Concentration and flow data were obtained from the Ministry of the Environment records.

In municipalities with combined domestic and storm sewer systems, some salt from deicing operations will pass through the sewage treatment plant. To separate the deicing salt component from the other sources of chloride (household, industrial, etc.) a baseline chloride concentration in sewage was established. Unlike baseline level calculations for tributary streams (developed above), sufficient concentration data were not available to calculate the baseline for individual STPs. All available records were separated to obtain the summer (May to October) records. A baseline concentration of 100 mg/l was selected and loadings for each plant were calculated by multiplying this value by the annual average treatment plant flows.

Table III: Summary of Total and Baseline Chloride Loadings from Sewage Treatment Plants Discharging Directly to Lake Ontario*

Year	Total Chloride Loadings tonnes/year	Baseline Chloride Loadings tonnes/year
1973	76,398	64,614
1974	105,880	65,680
1975	82,398	67,716
1976	105,583	72,464

*loadings from inland STPs are included in the tributary loading figures.

CHLORIDES FROM INDUSTRIAL DISCHARGES

Most industries discharge to municipal sewerage systems and loadings are included in the STP figures. Of the remaining, there are a few industrial discharges that are monitored for chlorides. For two of the larger industries discharging into Hamilton Harbour, the total chloride loading from 1973 was 42,547 tonnes. An estimate of 43,000 tonnes each was made for 1974, 1975 and 1976.

CHLORIDE FROM THE ATMOSPHERE

From the Ontario Ministry of the Environment records, the total loading of chloride falling on the surface of Lake Ontario from atmospheric sources for the period 1973-1977 was 75,000 $\pm$ 25,000 tonnes. For the purpose of this report, an annual average loading of 15,000 tonnes was selected.

The chloride inputs to Lake Ontario from Ontario sources outlined above, are summarized in Table IV.

Table IV: Summary of Measured Chloride Inputs to Lake Ontario (Excluding Deicing Salt Contribution)

	1973	1974	1975	1976
Tributary Streams (Baseline Loadings)	153,509	148,604	128,664	131,156
STPs (Baseline Loadings)	64,614	65,680	67,716	72,464
Industry	42,547	43,000	43,000	43,000
Atmosphere	15,000	15,000	15,000	15,000
TOTAL	275,670	272,284	254,380	261,620

CHLORIDES FROM DEICING SALT APPLICATION

Rock salt (sodium chloride) is used predominantly as the deicing chemical in Ontario. The chloride ion constitutes about 60% of sodium chloride by weight. In order to determine the magnitude of the chloride loading to Lake Ontario from deicing salt operations in Ontario, the total amount of salt applied each year by municipalities, the Ontario Ministry of Transportation and Communications and the public was converted to chloride loading and are presented in Table V.

Table V: Summary of Chloride Loadings from Deicing Salt Applications

Winter Period	Total Salt Application tonnes/year	Resultant Chloride Loadings tonnes/year
1973-74	315,048	189,030
1974-75	321,167	192,700
1975-76	405,035	243,020
1976-77	421,189	252,710

Because salt dissolves in water and does not generally settle in rivers and lakes or adhere to particulate matter when passing through soil, this report assumes that chlorides from all deicing salt applied in the basin ultimately reaches Lake Ontario. While this may not be strictly true in reality it does present the maximum loading rate or "worst-case" condition.

SUMMARY OF CHLORIDE LOADINGS

From the foregoing sections, it is quite evident that deicing salt is the largest single contributor of chlorides to Lake Ontario from Ontario sources.

In the following table (Table VI) the relative significance of each source category is identified. Because salt usage varies from year to year as mentioned earlier, the results of the four year studies are averaged to illustrate mean conditions. Baseline tributary and sewage treatment plant loading rates were employed to isolate the deicing salt contribution, (see pages 5 and 6).

Table VI: Relative Significance of Sources of Chlorides (Averaged for the Study Period 1973-1977)

Source	Tonnes/Year	Percentage of Total Load
Deicing Salt	219,370	45
Tributaries (Baseline)	140,480	29
Municipal STPs (Baseline)	67,620	14
Industry	43,000	9
Atmosphere	15,000	3
	485,470	100%

ENVIRONMENTAL SIGNIFICANCE OF CHLORIDES

1. CRITERIA

Domestic Water Supplies[1]

Chlorides in drinking water are generally not harmful to humans until high concentrations are reached. Restrictions on chloride concentrations in drinking water are generally based on palatability requirements rather than on health considerations. For average individuals, the "salty taste" threshold is about 400 mg/l although some taste-sensitive people can detect chlorides from sodium salts at about 120 mg/l.

The Ontario Ministry of the Environment criterion for chloride in public surface water supplies is 250 mg/l.

Industrial Water Supplies[1]

The chloride levels in water supply used for industrial purposes generally follows the 250 mg/l criterion for public water supply. The notable exception is the iron and steel industry where chloride levels of 150 mg/l are preferred to minimize the possibility of corrosion.

Irrigation[1]

High chloride levels in crop irrigation water can be toxic to plants. For most crops irrigation water should not contain more than 150 mg/l of chlorides. Specialty crops such as tobacco require much lower levels in the order of 70 mg/l.

Fish and Aquatic Life[2]

It is difficult to generalize on the effects of chlorides on fish and aquatic life. Levels as low as 400 mg/l have been reported to be harmful to trout and levels of 4000 mg/l have affected bass, pike and perch. Rather than high absolute levels of chloride, it appears that the rapid changes in chloride levels may have a greater impact on the health of fish.

2. CHLORIDES IN ONTARIO WATERCOURSES

In general, chloride levels in Ontario rivers and streams are well below the permissible criteria outlined above. For example, average chloride levels for various classification of watercourses in the Lake Ontario drainage basin are as follows:

Rural watercourses (no urbanization)	- 10-20 mg/l chloride
Semi-rural watercourses (with small municipalities)	- 30-70 mg/l chloride
Urban watercourses	- 100+ mg/l chloride

1. *Guidelines and Criteria for Water Quality Management in Ontario.*
2. *McKee, J.E. and Wolf, H.W. - Water Quality Criteria; State of California; 1963.*

In Figures 1 through 5, the chloride levels for four years have been plotted for several of these classifications of streams. The most notable characteristics shown on the plots are the low to moderate seasonal fluctuation of chlorides in the rural and semi-rural watercourses and the sharp fluctuation measured in urban watercourses.

The seasonal fluctuations measured in urban streams can be attributed primarily, if not wholly, to the use of deicing salt. The most dramatic rises occurred near the mouths of Metropolitan Toronto area streams. For example (see Table VA of the Appendix), the chloride levels in the Humber River registered a 460% increase at one point during the winter of 1976-77. In another year, the Don River and Mimico Creek showed 360 and 380% fluctuations respectively. While the lower reaches of these rivers are not used for water supply or irrigation, the peak winter levels and rapid chloride fluctuations may be stressing fish and aquatic life. Evaluating that impact is beyond the scope of this report.

3. CHLORIDES IN LAKE ONTARIO

The chloride level for open water areas of Lake Ontario is slightly less than 30 mg/l, well below the drinking water criteria and within the criteria for other normal uses.

A review of historical data on chloride concentrations in Lake Ontario (Figure 6) shows an increase from about 8 mg/l at the time of early settlement to about 29 mg/l in the early 1970's. The increase in chloride concentration parallels growth in the Great Lakes Basin and probably reflects the impact of land disruption for urbanization, the installation of sewage collection systems, industrial growth, etc.

Deicing salt came into prominent use following World War II with the rapid increase in the number of motor vehicles and roadway construction; however, despite the significant chloride loading attributed to deicing salt, Lake Ontario data do not show an accelerated increase in the level of chlorides over the past 30 years that could be attributed to deicing salts.

In fact, over the past few years, the concentration of chlorides has levelled out between 28-30 mg/l in the lake. The reason for this may be, in part, additional dilution through high lake levels or an equilibrium being established.

Unlike rivers, chloride levels in the open lake do not show a significant seasonal fluctuation. Daily chloride measurements from the Toronto Westerly Filtration Plant show no more than a 1 mg/l fluctuation at any time, and there is no measurable upwards winter trend.

Lake Ontario is the lowest lake in the Great Lakes chain and accepts the drainage from lakes Superior, Michigan, Huron and Erie. Salt mining and industrial activities in lower Lake Huron, the St. Clair-Detroit system, Lake Erie and the Niagara River, contribute significantly to the chloride level in Lake Ontario. To illustrate this point the mean chloride level in Lake Huron is about 6.0 mg/l whereas the mean chloride level in Lake Erie is 19.0 mg/l. The chloride level in Lake Ontario is mainly due to the transport of chlorides via the Niagara River from the upstream lakes, rather than from activities within the Lake Ontario drainage basin.

A comparison of the chloride loading contributed by deicing salts, 219,370 tonnes per year (see Table VI) and the chloride loading carried by the Niagara River, 4,620,000 tonnes/year*, shows that deicing salt chlorides are less than 5% of the Niagara River loading. Expressed in another way, the deicing salt chloride loading is equivalent to raising the chloride level in the Niagara River by 1.0 mg/l.

*Based on a Niagara River flow of 6,660 cubic meters per second and a chloride concentration of 22 mg/l. These data are representative of the mid-1970's.

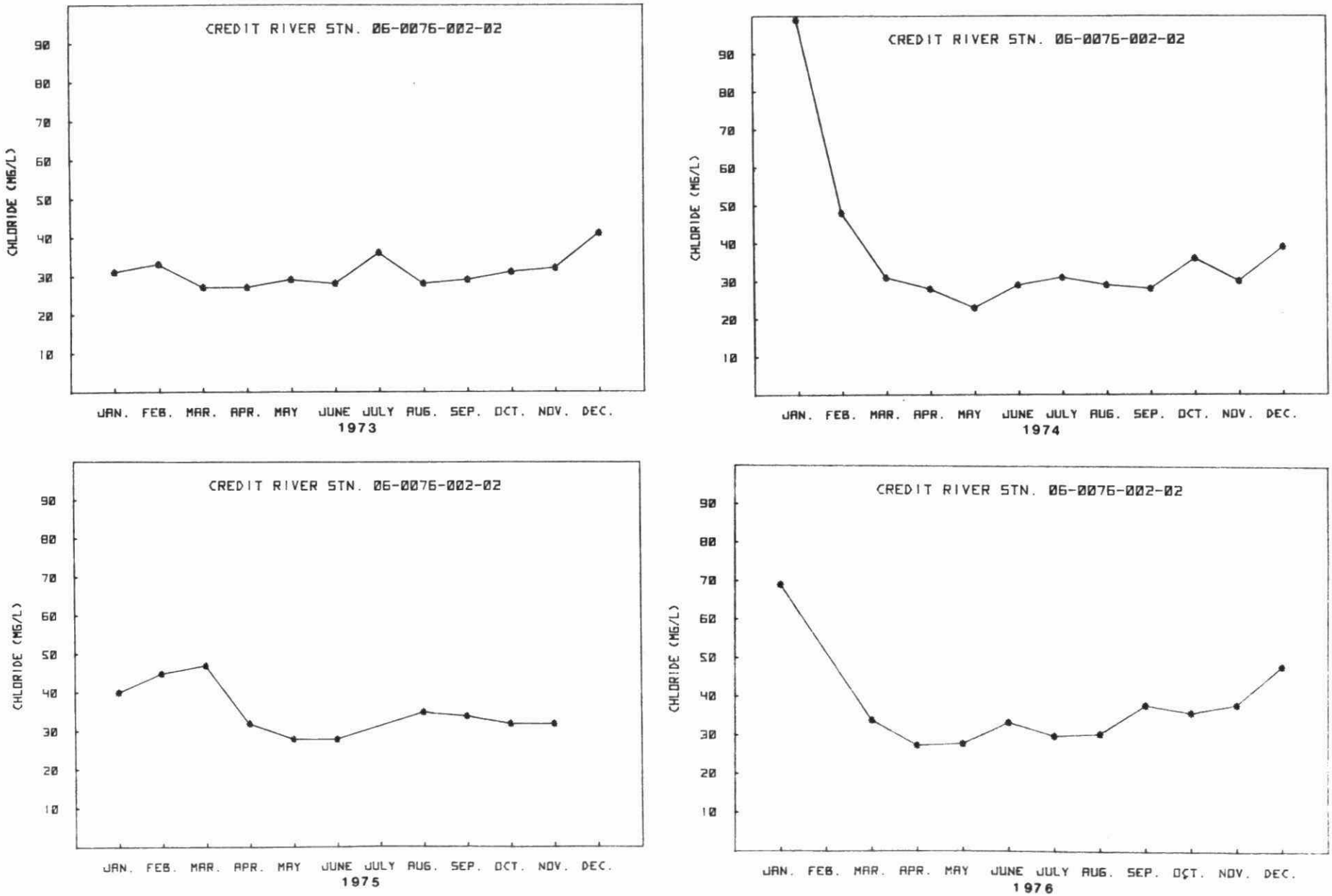

FIGURE 1. - CHLORIDE CONCENTRATION PROFILES FOR THE CREDIT RIVER (**SEMI-URBAN STREAM**)
(Sampling Location - Highway 5 Bridge)

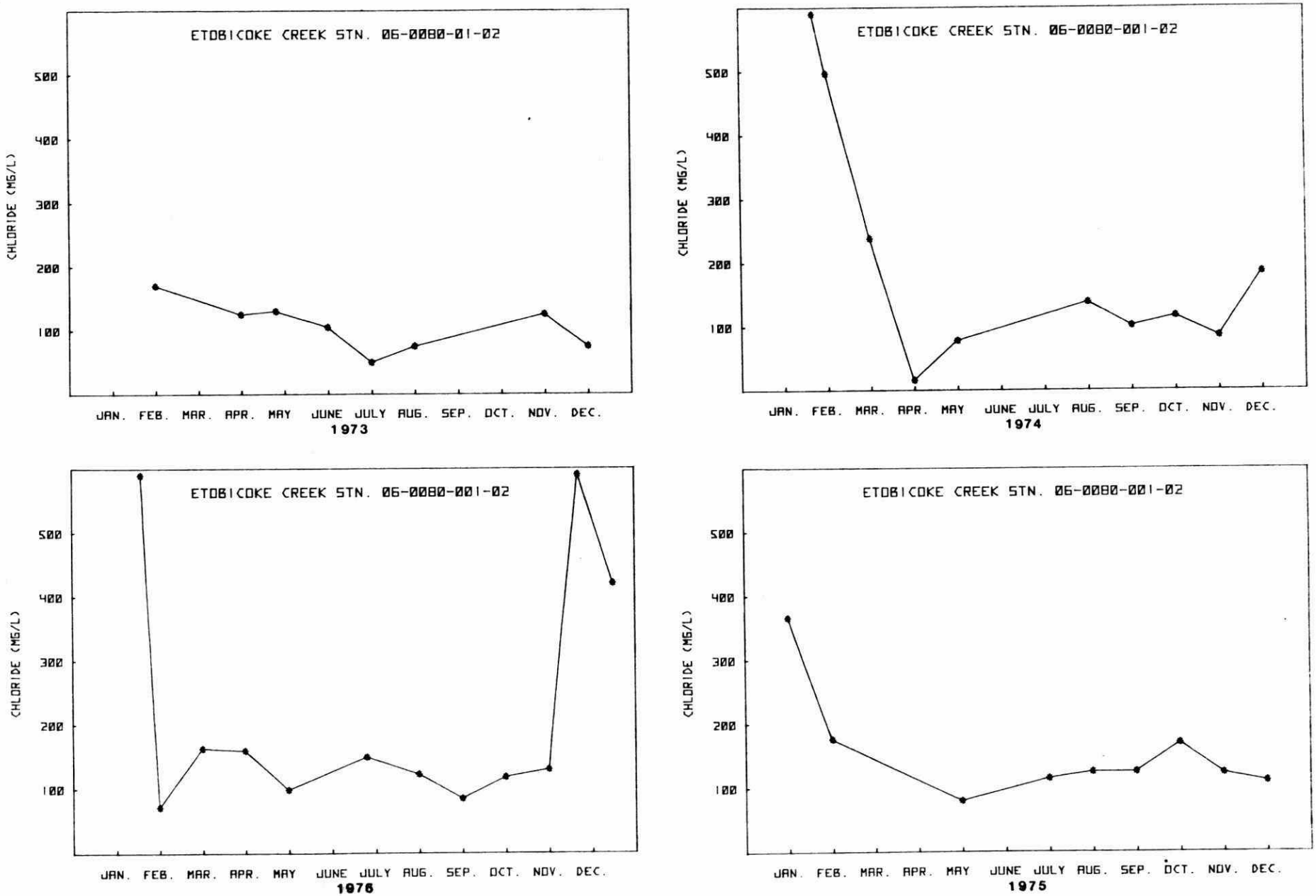

FIGURE 2. - CHLORIDE CONCENTRATION PROFILES FOR ETOBICOKE CREEK (UPBAN STREAM)
(Sampling Location - Highway 2 Bridge)

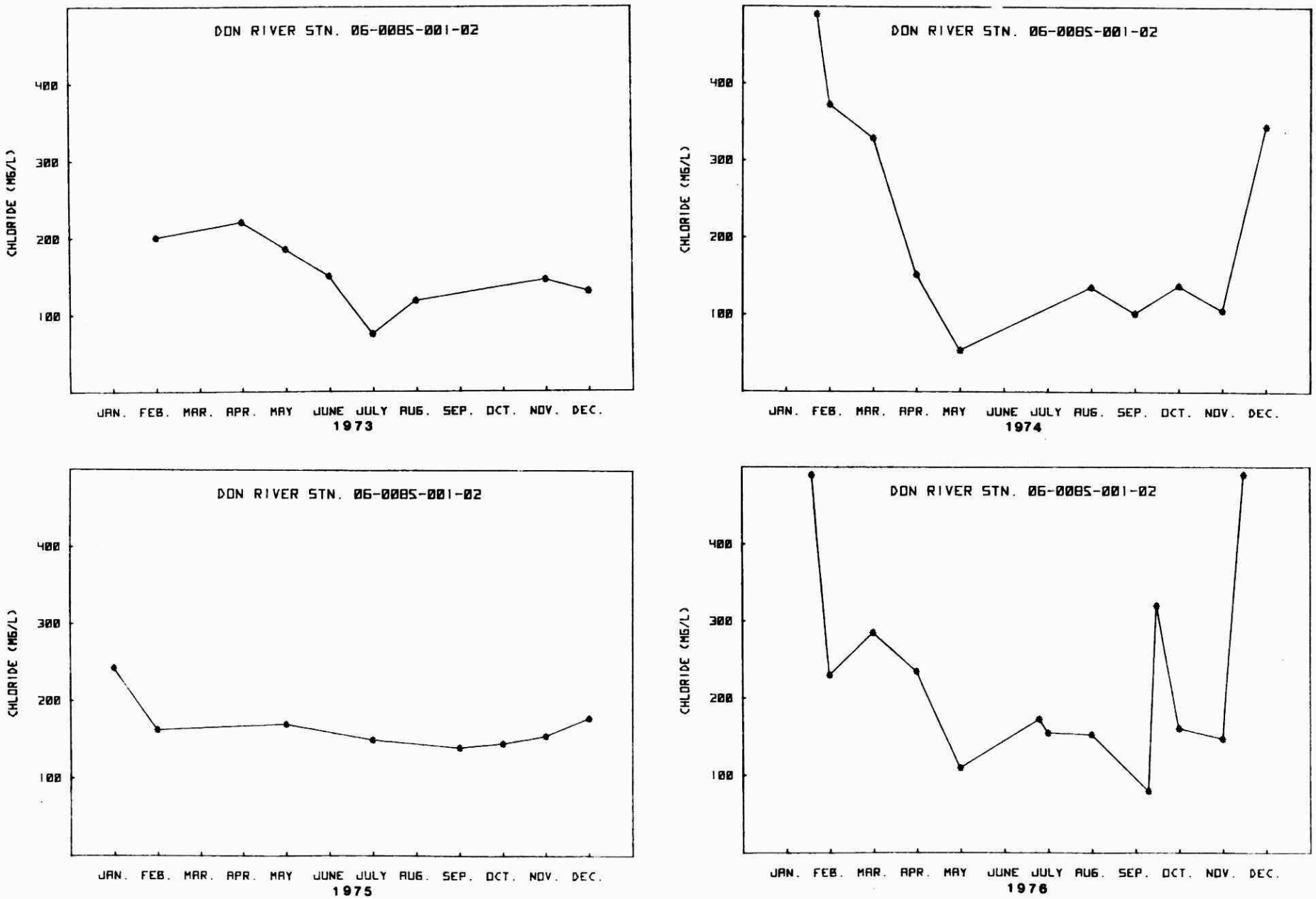

FIGURE 3. - CHLORIDE CONCENTRATION PROFILES FOR THE DON RIVER (URBAN STREAM)
(Sampling Location - Lakeshore Road Bridge)

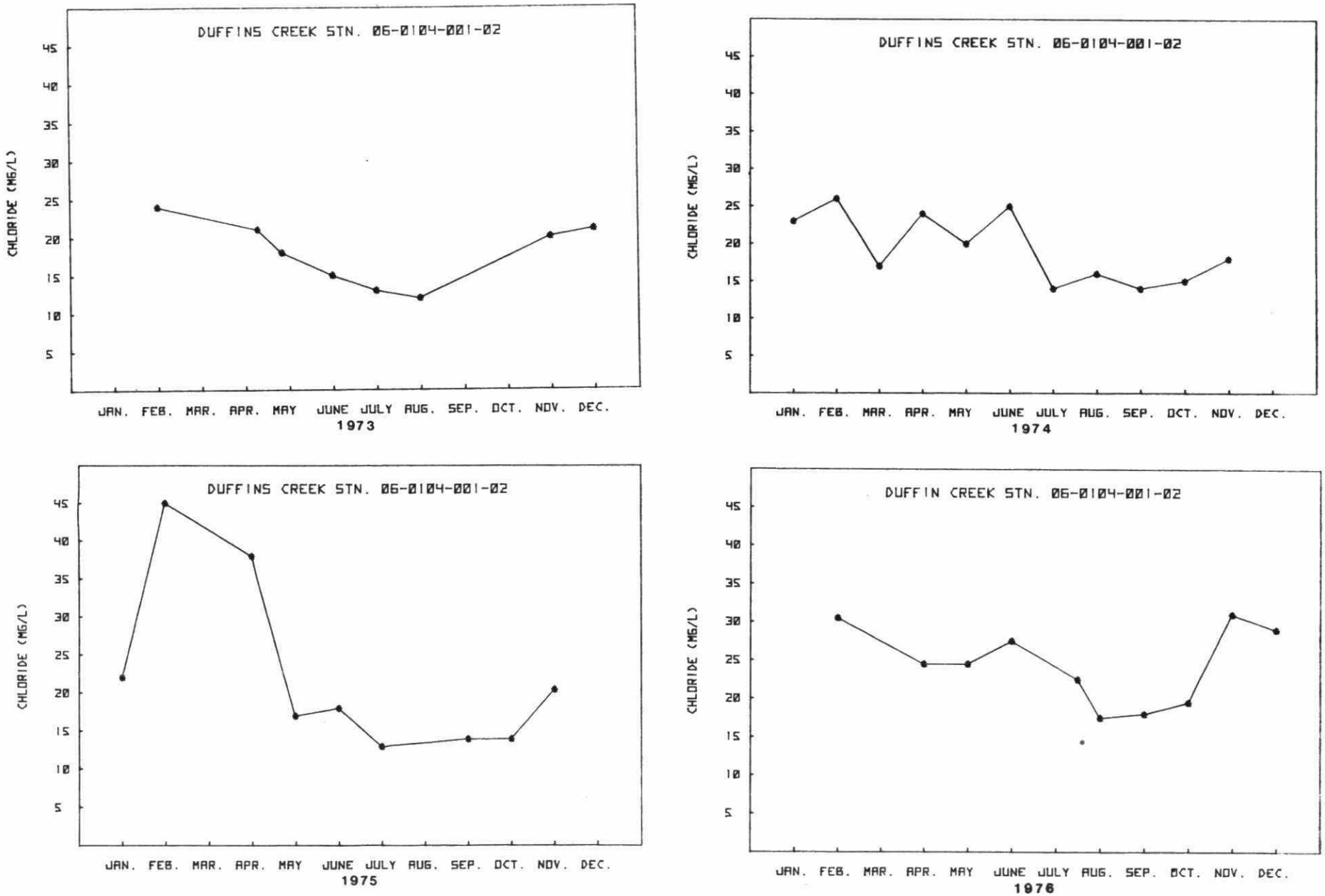

FIGURE 4. - CHLORIDE CONCENTRATION PROFILES FOR DUFFINS CREEK (SEMI-URBAN STREAM)
(Sampling Location - Baseline Road, West of Ajax)

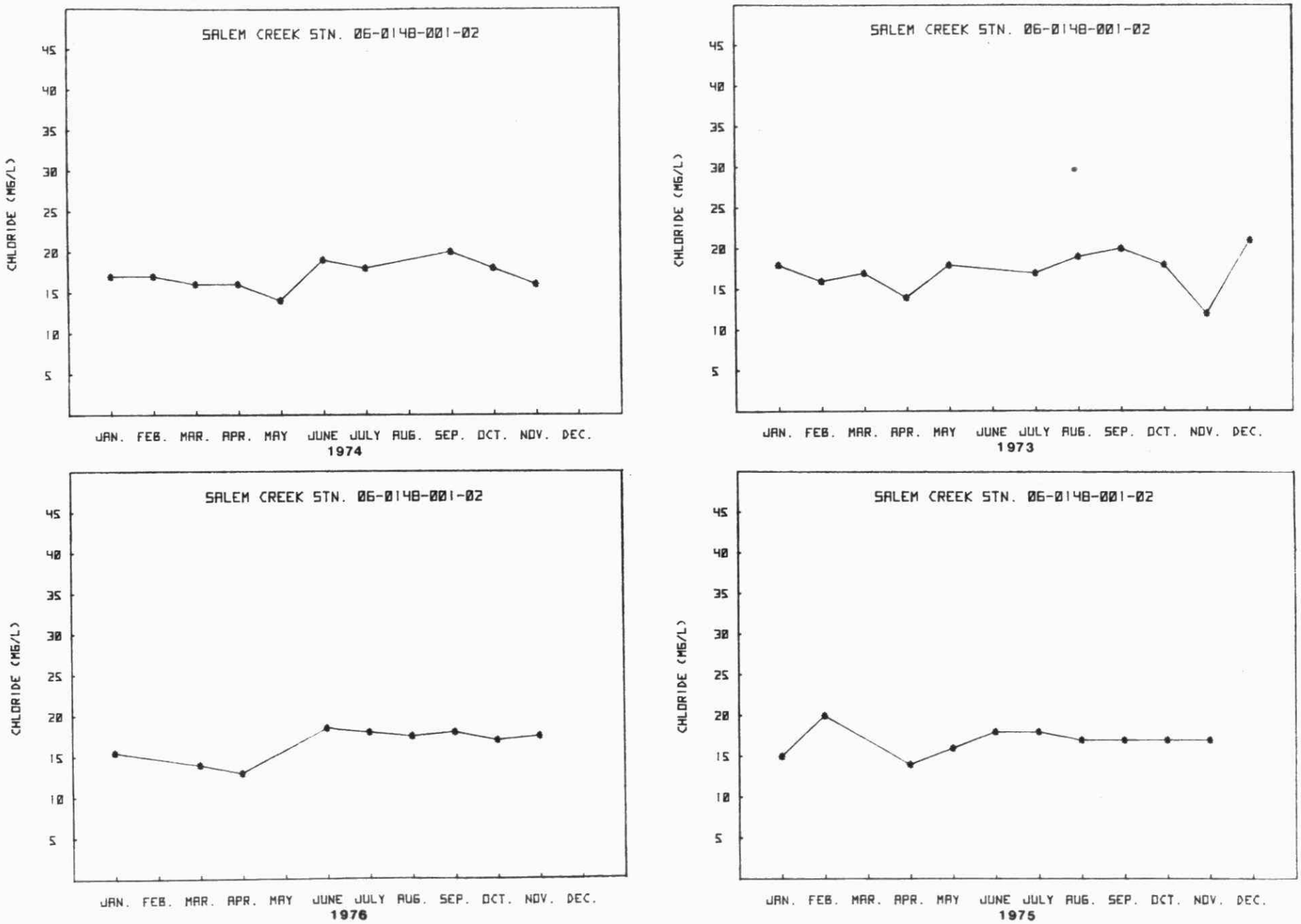

FIGURE 5. - CHLORIDE CONCENTRATION PROFILES FOR SALEM CREEK (RURAL BASIN) - S-E of Colborne

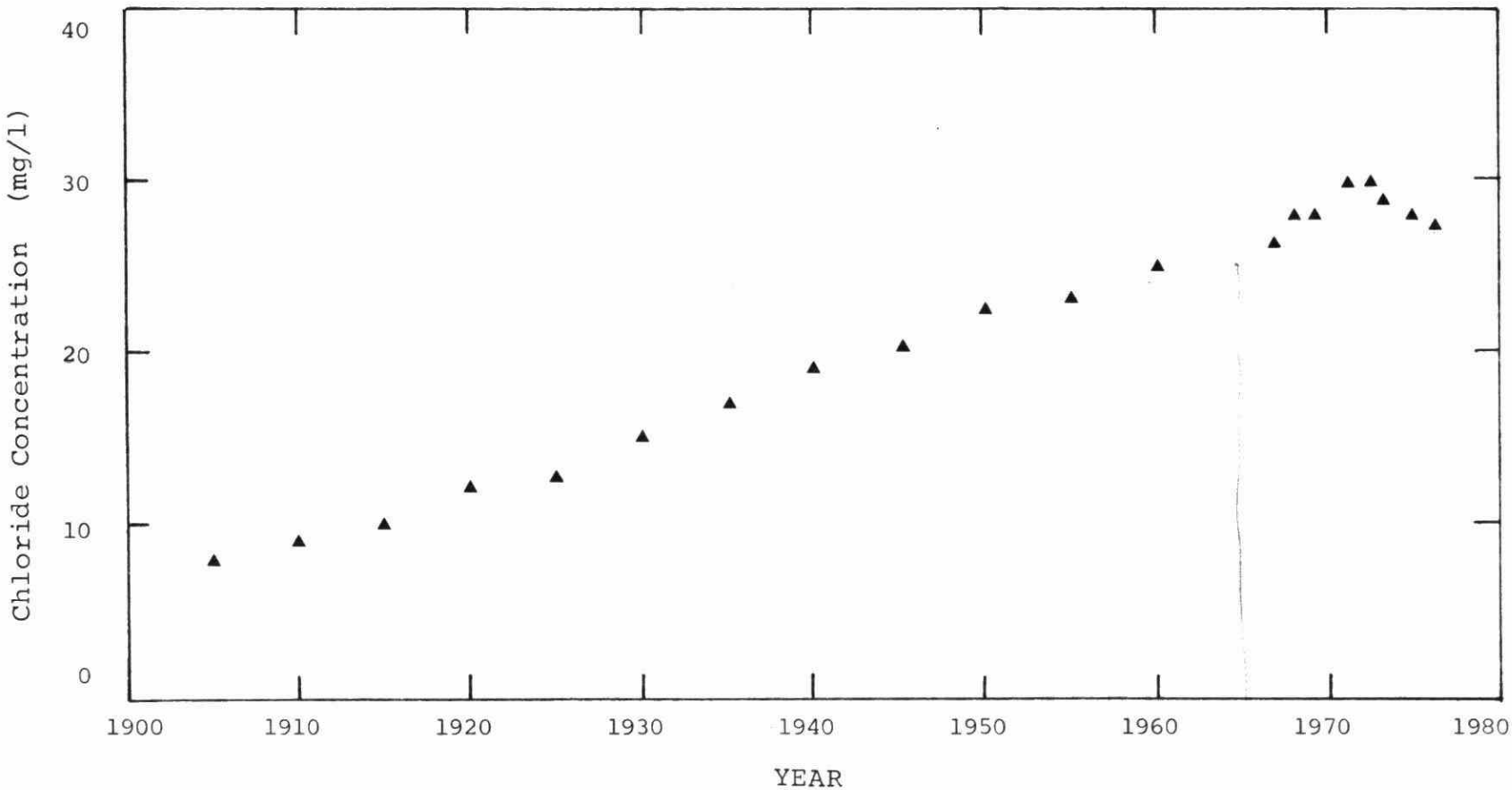

Figure 6. Changes in the chloride concentration of Lake Ontario (after Beeton 1965)

CHLORIDE INPUTS FROM NEW YORK STATE

The chloride inputs to Lake Ontario in the preceding sections are from the Province of Ontario. A similar breakdown of chloride inputs from New York State was requested but at the time of preparation of this report, the only information available were the chloride loadings for the three major New York tributary streams; namely, Genesee River, Black River and Oswego River. The loadings for the years 1973 to 1975 are shown below.

Table VII: Chloride Loadings for Three New York State Tributary Streams - Tonnes

Stream	1973	1974	1975
Genesee	181,730	173,410	187,140
Black	9,120	10,540	8,760
Oswego	1,421,230	1,374,000	1,192,130

In the 1971 Ontario Water Resources Commission report entitled, "Deicing Salt as a Source of Water Pollution", the Oswego River was identified as the major contributor of chloride to Lake Ontario. The 1971 report included tributary loadings and estimated deicing salt loadings for the New York portion of the basin, the Oswego River input (about 1 million tonnes per year at that time) represented about 60% of the total chloride load to Lake Ontario. As a result, deicing salt loading was calculated to be significantly lower, in the order of 20% of the total loading. It is estimated that, if a complete set of N.Y State loadings were included, deicing salt would once again comprise about 20% of the total chloride loading. As mentioned in the 1971 report, exclusion of the Oswego River loading would increase the proportion of deicing salt to over 40% of the total loading. This is in line with the findings of 1977 survey of Ontario sources.

DISCUSSION

From the information presented in this report, it is readily apparent that deicing salt is the largest single, local contributor of chlorides to Lake Ontario from Ontario sources. It is not evident, however, that this source is having an adverse impact on lake-wide water quality. The influence of the Niagara River, carrying chlorides from sources in the "upstream" lakes, is over 20 times greater than the deicing salt contribution.

While the impact of deicing salt on the general quality of Lake Ontario may not be significant, its local impact can be quite pronounced as evidenced by the major fluctuations in chloride levels in rivers and streams flowing through highly urbanized areas. Large fluctuations with high winter chloride concentrations are presently limited to the lower reaches of streams in the Metropolitan Toronto area where uses such as water supply and irrigation are not practiced, water use impairment could result downstream of large urban centres built in headwater areas or upper reaches of watercourses. When evaluating the environmental consequences of urban development or expansion, therefore, the impact of deicing operations must be considered.

Citizens living in the larger municipalities of southern Ontario expect that roadway maintenance agencies will provide "bare-pavement" conditions whenever possible. This can be practically achieved today only through a program of plowing and the application of a chemical deicer. As mentioned earlier, sodium chloride (rock salt) is the only effective and economical deicing chemical currently available for widespread use.

Snow plowing and removal are necessary components of winter road maintenance programs in most municipalities. While deicing salt does not significantly affect the chlorides level in Lake Ontario, this by no means condones the practice of snow disposal directly to Lake Ontario or any other watercourse. Salt is only one of many contaminants found in snow removed from roadways. The purpose of the Ministry of the Environment's ban on direct disposal of snow is to ensure that other pollutants such as oxygen demanding organic materials, heavy metals, oils and detritus are not introduced to watercourses. For further details on snow disposal procedures, refer to the Ministry of the Environment publication "Guidelines for Snow Disposal and Deicing Operations in Ontario".

In conclusion, the continuing urban growth and highway development and the public demand for "safe" conditions, the use of deicing salt will continue to grow. Realistic alternatives are extremely limited but might include:

i) Development of an environmentally safe deicing compound that is effective and inexpensive enough for widespread use;
ii) Make the use of snowtires (perhaps with studs) mandatory and maintain snow-packed roads;
iii) Encourage wider use of public transit and selectively remove snow for bus lanes, etc.

Until alternatives precluding the use of deicing salt are found, there are measures that can limit the amount of salt used. These measures, included in the 1975 Ministry of the Environment publication entitled "Guidelines for Snow Disposal and Deicing Operations in Ontario", are as follows:

1. Deicing Salt - Application

(a) Reduce salt application rates to the minimum amount necessary to successfully do the job. Experience has shown that an application rate in the order of 400-500 pounds per two-lane mile is usually sufficient. If the desired effects can be achieved with less salt then these lower rates should be applied.

(b) Employ rate-controlled salt distribution equipment which operates independently of the vehicle's speed.

(c) Salt only main thoroughfares and critical sections of other roadways, such as inclines, intersections, crosswalks, etc.

(d) Where salt/sand mixtures are applied (usually in northern municipalities and on rural roads) incorporate into the admixture only enough salt to achieve the desired results.

2. Deicing Salt - Storage

Road salt or sand/salt stockpiles should always be protected from precipitation or surface runoff. Further, the storage facility should be underlain with an impervious apron (preferably asphalt) and dyked to prevent the seepage of salt leachate from the storage area to a nearby watercourse or to ground-water aquifers.

Permanent storage structures afford the best protection and we urge the installation of such structures whenever possible. Other methods of protection such as polyethylene sheets and spray coating have generally proven to be less effective, but are certainly a better alternative to open storage until permanent structures are installed.

The Ministry of the Environment guidelines have been widely distributed throughout Ontario and most roadway maintenance agencies have taken or are in the process of implementing steps to follow these guidelines and reduce the use or loss of salt.

Copies of the Guidelines can be obtained by contacting Regional Offices of the Ministry of the Environment or by writing to the Water Resources Branch, Ministry of the Environment, 135 St. Clair Avenue West, Toronto, Ontario, M4V 1P5.

APPENDIX

TABLE 1A - SALT APPLIED BY TOWNS AND MUNICIPALITIES - TONNES

	1973-74	1974-75	1975-76	1976-77
Toronto (City)	28717	21947	26326	34003
Halton	1000*	1089	6654	4850
Milton	950	998	1498	1428
Niagara	7904	10832	12712	14721
Port Hope	412	440	495	613
Trenton	635	645	959	931
Stoney Creek	4717	5442	5442	2993
Niagara Falls (City	2027	3542	3915	5946
Caledon	1100*	1179	1314	1387
Pickering	702	1259	1796	1754
Belleville	1377	1622	1049	2380
East York	2942	3175	4483	4712
Whitby	1022	1391	2123	2613
Ajax	1000*	1050*	1088	1179
Brampton	2268	5442	5442	5442
Metro Toronto	43615	42690	55695	69453
Oshawa	6712	6349	7256	6484
North York	28099	26376	32163	26730
St. Catharines	1510	2268	3286	3648
Kingston	2751	2751	4258	2732
York	4247	4331	5605	5316
Cobourg	246	343	319	363
Peterborough	3808	2059	4786	4926
Scarborough	17234	13968	24036	26304
Hamilton	15274	13969	16013	21116
Halton Hills	1088	1088	1088	1088
Mississauga	7256	10204	12641	17882
Richmond Hill	1495	1622	1790	1898
Etobicoke	14785	14331	17596	17234
Newcastle	3500*	3583	3684	2156
Oakville	5290	2916	5328	2763
TOTAL	213683	208901	270840	295545

*Estimates

TABLE IIA - SALT APPLIED BY THE MINISTRY OF TRANSPORTATION AND COMMUNICATION

Year	Total Salt Used (TONNES)	Total Highway Miles Salted in Ontario	Deicing Salt Applied to Highways in the Basin* (TONNES)
1973-74	346,709	12,730	86,680
1974-75	388,745	12,730	97,190
1975-76	475,241	12,850	118,810
1976-77	440,410	12,850	110,110

*The amount used by MTC on highways in the Lake Ontario basin was estimated as being 25% of the total salt used throughout the Province. This estimate was based on the following factors:

1. Low temperatures in northern Ontario often preclude the use of salt alone because its effectiveness is reduced.

2. In south-western Ontario in the vicinity of Lake Erie and Lake St. Clair, the winters are somewhat milder than in the study area and therefore less salt is required.

3. The large population and traffic density in the study area require that the highways are kept ice free at all times. This suggests that salt is more frequently applied on the highways in the study area.

TABLE IIIA - CHLORIDE LOADINGS FROM TRIBUTARY STREAMS - TONNES

Stream	1973	1974	1975	1976*
Four Mile Creek	736*	649*	783*	938
Six " "	753*	1113*	1357*	3129
Eight " "	105*	130*	185*	376
Twelve " "	146985	182127	158853	145085
Twenty " "	7676	5896	4205	7140
Stoney Creek	1613*	2188*	2069*	4229
Redhill Creek	1732*	1624*	2021	1611
Spencer "	2514	1917*	2129*	1404
Bronte "	2169	2663	2084	2046
Oakville "	1524	1966	1769	1470
Credit River	9790	11978	9471	8127
Etobicoke Creek	7372	14500	7899	12643
Mimico Creek	3174	10272	3560	5271
Humber River	13343	32634	12683	19569
Don River	19940	41757	16892	29145
Highland Creek	5288	5266	3449	8668
Rouge River	2982	2700	2952	2905
Duffins Creek	1499	1546	1669	1944
Pringle "	1461*	1057*	590*	1171
Oshawa "	1665	1787	1446	1567
Bowmanville Creek	337	972	853	931
Wilmot Creek	434	441	377	463
Ganaraska River	1101	1160	1204	1064
Cobourg Brook	2462*	2021*	1780*	2402
Shelter Valley Br.	145*	278*	193	221
Salem Creek	111*	104*	85*	89
Smithfield Creek	171*	156*	315*	203
Grindstone "	1884	975	1431	1321
Trent River	34340	33524	20767	22529
Moira "	6805	4858	6638	6125
Salmon "	2700	2878	2040	1443
Napanee "	3845	2506	2059	1859
Millhaven Creek	1335*	886	1928	1214
TOTAL	287891	374529	275726	298338

*Estimates

TABLE IVA - CHLORIDE LOADINGS FROM SEWAGE TREATMENT PLANTS - TONNES

	1973	1974	1975	1976
Niagara on the Lake	49	59	53	80
St. Catharines (P.Weller)	1385	1019	1048	920
St. Catharines (Port Dalhousie)	1581	1008	1213	1692
Lincoln	54	75	114	87
Grimsby A.S.	39*	48*	46*	48*
Grimsby (Beach)	12	12	9	7
Grimsby (Twp. N.)	23	29	42*	29
Hamilton	11177	11974	12016	16618
Burlington (Skyway)	1584	2038	2255	3048
" (Drury La.)	315	341	347	276
" (Eliz Gardens)	147	136	141	139
Oakville (S.W.)	1291*	1384	1292	1610*
" (S.E.)	182*	211	280	411*
" Ford Motor Co.	28	30	27	24
Mississauga (Lakeview)1	1807	2378	2868	3248
" (Lakeview)2	3663	4476	4742	6402
" (Clarkson)	596	1360	1967	1781
Metro Toronto (Humber)	14682	15660	15852	19101
" " (Main)	33436	51615	32946	42923
Pickering Twp. (Bay Ridges)	194	233	367	397*
Whitby	45	61	51*	51*
Oshawa	1700	2171	2691	3519
Port Hope	756	688	491	1302
Trenton	478	445	385*	419*
" CFB	53	55*	44*	41*
Belleville	845	8111*	824*	1056*
Picton	34	34*	50*	50*
Deseronto	19	22	24*	26*
Vill. of Bath	24	36	15*	20*
Kingston Twp.	199	191	198	258
TOTAL	76398	105880	82398	105583

*Estimates

TABLE VA - CHLORIDE CONCENTRATIONS IN STREAMS
IN AND AROUND METRO TORONTO

STREAM	1973-74		1974-75		1975-76		1976-77	
	B	W	B	W	B	W	B	W
Oakville Cr.	31	38	31	59	40	47	39	55
Credit R.	30	44	28	40	31	40	32	41
Etobicoke Cr.	77	367	91	183	111	301	104	235
Mimico Cr.	90	611	89	215	130	518	98	321
Humber R.	63	205	68	107	64	153	61	339
Don R.	111	514	101	199	145	285	155	353
Highland Cr.	108	169	104	-	104	258	141	392
Rouge R.	62	62	66	74	73	74	61	124
Duffins Cr.	21	33	23	32	16	22	20	29

* B = Baseline conc. mg/l
W = Winter " mg/l